

Strictly on track

- Lotus Driving Academy

Well-to-‘two wheels’

- a vision of the future of
MotoGP

Lotus and HEVs

- those we can talk about

The North Carolina Centre for Automotive Research

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ground



Welcome

It is widely held that Lotus cars are amongst the finest handling in the world, and many engineering clients can attest to the dynamics and refinement benefits Lotus Engineering can bring to their vehicles. These are the result of the expertise of our design engineers to lay the right foundations and for our development engineers to realise the vehicle's full potential, something made possible by where we test them.

We are blessed around Hethel with both fine and terrible roads. Sweeping country lanes and harsh concrete dual-carriageways provide the highs and lows of my journey into work and the proving ground for many cars. But much of the hard work relies on extensive laps around the Lotus test track. It has been modified and fine tuned over the years so that today it is a circuit that can explore and expose every aspect of both a vehicle's and a driver's capabilities.

Driving enthusiasts can now experience our test track and develop their skills in our new driving academy, and we have also been passing on our insight into test facility design. From helping with the design of the BBC *Top Gear* test track to the new NCCAR facility in the US that we have been involved with since its inception, the influence of Lotus's driving dynamics engineers continues to spread beyond just the cars they have touched.

A profile of the driving academy and the progress of the NCCAR facility are among the features in this issue. As ever, enjoy.

Peter Morgan

Marketing Manager – Lotus Engineering



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US: Chevy Volt updates faster, easier

General Motors will be able to upgrade its battery-powered 'range extender' Chevy Volt much faster than conventional vehicles due to its new technology, an executive has said.

Frank Weber, GM's global vehicle line executive for the Volt, said at an event ahead of the Chicago motor show: "This is almost like getting software updates into your car. This is not a mechanical world. This is suddenly you get updates, improvements much more rapidly."

"So, even within a vehicle life cycle, you will see updates that are very significant," he was quoted as saying by Reuters.

GM, which expects to begin production of the Volt in 2010, has not said when it expects to roll out the second generation of the vehicle, but plans to focus on cutting the size and cost of the battery as a top priority, Weber said.

Weber also said his priorities included driving down the size and cost of the Volt's lithium-ion battery for future versions.

The 181kg (400lb) T-shaped battery pack is expected to be the Volt's most expensive element and most important component, according to Reuters. Its cells will be manufactured by Korea's LG Chem, GM said last month.

Weber told Reuters GM engineers were not focused on extending the vehicle's range beyond 40 miles (64km), a distance seen as the longest most people would drive the car on a daily basis.

"My goal is not to go from 40 to 60 (miles/64-100km) in the next generation vehicles," he said of the Volt's range. "My expectation is that the battery is equally capable, but they are half the size and half the cost of the batteries that go into the car right now."

The drive system designed for the Volt could be applied across the automaker's entire lineup over time, but that is not something Weber said he envisions now.

GM's German unit Opel has already promised a derivative called the Ampera.

"Before we talk about diversification on the portfolio side, there is enough market for a vehicle that provides this level of functionality and performance," Weber said.

The Cadillac Converj concept car GM shown at the Detroit auto show in January demonstrates the Volt system could work in a higher-cost luxury model, he added.

Weber also claimed the Volt project set GM apart from other automakers that have been developing pure battery electric vehicles, hybrid electric vehicles and plug-in hybrids, Weber said.

GM believes the Volt's battery-driven system will remain viable over several generations, and battery technology will not progress for some time to a point where pure battery electric vehicles can range hundreds of miles at an affordable price, he noted.

The automaker has taken great pains to deliver on its plan for a 40-mile pure-battery range for the Volt, down to reducing tyre friction and the battery drain from electronics such as stereos.



GM said on Tuesday Goodyear would provide new tyres that have less rolling resistance while Bose would produce an optional premium sound system that would weigh less and use less electricity, Reuters noted.

GM plans to build about 10,000 Volts in its first year and eventually hike annual output to about 60,000. The car's battery can be recharged at a standard electric outlet.

The report also noted GM had said it did not expect to make money on the first generation of the Volt, making its subsequent launches more important.

Source: just-auto.com editorial team

FRANCE: Renault's Dacia adds LPG and E85 engines

Renault's low-cost Romanian Dacia car unit has widened its range of economical and 'eco-friendly' engines to include new versions powered by liquid petroleum gas (LPG) and E85 bioethanol. The new Sandero E85 model emits as little as 60g/km on the sugar cane-based E85 fuel available in Sweden and 130g/km on the sugar beet/wheat-based E85 fuel made in France.

The automaker has also just launched a new 1.2 16V petrol engine.

All the new powertrains will be launched Europe-wide this year. They are: 1.4-litre, 75hp LPG Logan (sedan) and Sandero (hatchback), 1.6-litre, 90hp LPG Logan MCV (wagon), 1.6-litre E85 Sandero and 1.2-litre 16V Logan and Sandero.

Renault said LPG reduces CO₂ emissions by up to 12% compared with petrol power and reduces emissions, is competitively priced, and is also eligible for tax incentives in several countries including France, Italy, Ireland, Portugal and Germany.

It's also readily available at 32,000 service stations in Europe. LPG vehicles are 60% quieter than diesel-powered vehicles, too, the automaker said.

The LPG Dacia models are dual-mode petrol/gas vehicles and the driver manually selects petrol or gas mode. Record driving ranges are achievable – the Sandero 1.4 LPG, for example, can travel up to 1,200km (750 miles) on a combined fill of both petrol and gas.

Safety features on the LPG gas system include a non-return valve, an 80% tank-fill limiter, fuel flow limiter, solenoid and shut-off valve. Servicing intervals are the same as for petrol-only engines (every 30,000km/20,000 miles or two years) with additional maintenance of LPG-specific items.

Renault has been making E100 flex-fuel engines since 2004, initially in Brazil. Its 1.6-litre dual-fuel petrol/E85 engine (first sold here in the UK in the Megane at the end of 2007) has sodium-filled valves which are extremely resistant to high temperatures, optimised cylinder head cooling and oil jet-cooled pistons. Performance is identical to the equivalent petrol engine, the automaker said.

The new 1.2 16V petrol engine for the Logan line emits just 139g of CO₂/km and has an EU combined cycle fuel consumption of 5.9 litres/100km.

Work to lower idle speed to 650rpm (from 750rpm) gives an urban fuel consumption gain of 2-3%. It is the first Renault engine to run with such a low idle speed.

Source: just-auto.com editorial team



INDIA: Toyota may assemble Camry locally

Toyota may make its globally-popular Camry sedan in India, the deputy managing director of its Indian subsidiary has said.

Local assembly would allow the car to escape the huge import duty on imported cars and may bring down its price by as much as 20-25% if the company passes on the entire benefit to buyers, the *Economic Times of India (ETI)* said.

The model is currently made in the US and Australia and assembled from kits in other markets such as Vietnam and Russia.

The fully-imported Camry currently attracts a composite import duty of 110% in India where it competes with cars like the Mercedes C Class and Skoda Superb in the country's 8,000-units-a-year premium segment, the paper added.

If locally produced, its lower price would pitch it against the (also locally assembled) Honda Accord, Hyundai Sonata and Skoda Laura in the much larger 25,000-cars-a-year executive segment.

Toyota operates a joint venture in India with Kirloskar Group Toyota Kirloskar Motor (TKM).

TKM deputy managing director (marketing) Sandeep Singh told *ETI*: "We are contemplating local assembling for Camry depending on volumes. It is one of our flagship products and we are selling in excess of 500 cars per year."

ETI reported Toyota also is mulling launching the Fortuner SUV in the Indian market sometime later this year. It would be imported in completely knocked down (CKD) kit form for full local assembly, again dodging the huge import duty on assembled vehicles.

TKM MD Hiroshi Nakagawa told *ETI* - "After a decade of operations in India, we are increasing our focus here. We plan to launch an all-new 'strategic small car' platform for India and other emerging markets and would also utilise Indian talent for product development."

ETI wrote Toyota missed its India sales target of 60,000 vehicles for calendar year 2008 by around 14%, selling only 51,803 units. "The difficult period in the domestic market will continue for the next couple of months. We hope it would start showing improvements by March and revive by the second half of 2009. We shall adjust our production as per the market demand," Singh said.

As a temporary measure it had cut production at the existing plant in Bangalore by 30% until March 2009 on the back of falling demand. The company would also launch a few more models from the global range such as the Land Cruiser.

ETI noted that Toyota has committed to setting up its second manufacturing plant in Bangalore by 2010 and moving ahead with its expansion plans but a separate unsourced report in Japan's *Nikkei* business daily today said this had now been delayed until the end of 2010 and that Toyota had dropped plans to also make the Corolla in the second plant as well as the existing facility.

Source: just-auto.com editorial team

2-Eleven takes on Dubai 24-hour

The Lotus 2-Eleven GT4 Supersport made a strong endurance debut at the Dubai International 24-hour race last weekend.

Malaysia-based Empire Motorsports ran the 2-Eleven GT4, with regular drivers Denis Lian and James Mitchell joined for this race by Torro Rosso F1 test driver Karun Chandhok. The majority of the mechanics in the up-and-coming Malaysian team are students studying automotive technology at The Otomotif College (TOC). The race team is part of Empire Motorsports' mission to develop a stronger foundation for the Asian motorsports industry.

The car qualified 36th overall for the race after the team elected not to stress the car unnecessarily immediately prior to such a long event. Within a few hours of the start the car had moved up to second in class and continued to climb through the overall rankings. At three-quarters distance the car was running in a very creditable ninth overall and second in class.

Sadly, after 18 hours of hard racing, a failure of the special-purpose sequential racing gearbox resulted in a costly three-hour gearbox change, dropping the 2-Eleven GT4 down to tenth in class and 50th overall. The drivers then rewarded the team's efforts with spirited progress and regained a number of positions completing the race eighth in class and 44th overall out of 59 finishers.

Mike Kimberley CEO of Group Lotus plc, commented: "Lotus is proud to have continued to develop our relationship with Empire Motorsports starting from the Merdeka Millennium 12-hour race at Sepang, Malaysia. Empire Motorsports has now demonstrated that the 2-Eleven GT4 also makes for an exceptionally competitive and cost-effective endurance race car capable of taking on much larger and more expensive cars in motorsport events."

Ashraff Dewal, Team Principal of Empire Motorsports, expressed delight with the pace of the 2-Eleven GT4 and the exceptionally low rate at which it consumed tyres and brake pads compared with the other participating racecars, commenting: "I am very proud that a young team like Empire Motorsports can work so closely with such an established marque as Lotus to develop a new endurance race car specification and I look forward to continuing the relationship in the future."

Chris Arnold, Head of Lotus Sport, said: "The 2-Eleven provides a platform to create a competitive, versatile race package that offers great thrills and performance," adding: "the 2-Eleven has been exceptionally well received and as well as driving the cars on the road, some owners have used 2-Elevens of various specification in many exciting and varied events from track days, rallies, hillclimbs, sprint races and international GT races. This race result shows that endurance racing must now be added to the 2-Eleven's impressive range of capabilities."

Source: Lotus Engineering



Strictly on track

– Lotus Driving Academy

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Throughout the levels you get to drive an Exige, Elise R and Elise S

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With a driver training syllabus to rival the world's greatest drive schools, delivered by tutors that are renowned ride and handling masters, The Lotus Driving Academy is unreservedly one of the most exciting initiatives to come from Lotus this year. With a planned start date of March 2009 and enquiries already pouring in, we get out on the tarmac to find out more.

Development engineer Dave Minter welcomes us onto the Hethel test track. He is tutoring some 'test' pupils in preparation for March 2009 when the Academy welcomes its first new trainees. Tutelage by Development Engineers, we ask, surely they have enough to do already? "Well, it's like this," he tells us. "Nobody knows the cars like the engineers that develop them, those that are responsible for the ride and handling of the car, the responsiveness and driveability of the vehicle, what better instructor for teaching even the most experienced how to handle a Lotus?"

Indeed, one can't argue with that. It explains why, at racing circuits around the UK, the track talk has centred on going back to school. Demon-driver wannabes have been enthused by the thought of the new driving academy. At a recent Silverstone club meet, Lotus Club member Thomas Mulhearn told us: "There's already a waiting list, I've put my name down and am prepared for a wait, I'm serious about taking part." He is not alone. As the ever-popular track events begin to be rostered onto next years calendar the academy places are filling up in preparation. "It's all about pushing yourself harder, learning just what your car can do and indeed what you yourself can do with it!" says track supremo Angelo Resonar, leaning against a battle-ready Exige S. "I'm looking forward to seeing what they could teach me," he says, half-jokingly.

The Academy tutors are unphased by such bravado and, having been responsible for honing the skills of some of the greatest drivers to have ever lived, or indeed raced, you can understand their confidence.

The school has thrown away the rule book in putting together a comprehensive and unique activity programme designed to transform a novice motorist into an experienced and skilled driver.

"We've created a completely new training programme, a well-rounded course that will really benefit drivers, no matter what their skill level" says Minter. "The Academy truly acknowledges the participants' expertise, presenting them with a licence that demonstrates their



progress," he says. "I think we now have the right balance where if attendees need more time on a subject, this course enables them to do just that, plus it allows everyone to learn to their own timescale."

The new course is structured into tiers, starting with Bronze, going up to Silver, then Gold. Once you gain your licence in each level, then you are able to progress to the next tier. For the truly experienced pupil that successfully conquers the gold stage; they can then go onto the Platinum level allowing them to take advantage of some 1:1 training with their instructor at their track of choice, for at this point they'll be able to drive any track in the world.

To get to this point though, you have to put the time in. "There's much more theory now, you spend half your time in the classroom," says Minter. It's about learning the technicality behind the car, so you understand it, and its potential responses. Then, once you are out on the tarmac, you can see how each component effects the car, for example what happens if you change the anti-rollbar, widen the tyres, or change the suspension geometry. Lotus also demonstrate that some of the much-heralded after-market accessories are just no good, and can actually degrade the car. What's the point of having more power; if you cannot handle it?

The Bronze stage kicks off with a technical tour of the factory. This is not to be confused with the factory tour, for the technical tour goes further in answering questions such as why the dampers are fitted upside-down. Then you get a drive of the North track where the entry, apex and exit cones are positioned to give you reference points, to aid your learning and confidence with the car.

The Silver level is akin very much to the current driver training day, in that you will get to drive the full track but this time you are given more lee way in that here only the entry and apex cones are positioned for you. When it comes to exiting the corners, you now have to navigate these freely with your instructor.

It's not until you get to the Gold level that you really are in 'stabilisers off' mode. You now get to drive the full track, the South track and the North track (anti-clockwise). This is much more of a challenge; here there are no cones at all. Entry, apex and exit cones are all removed.

Throughout the levels you get to drive an Exige, Elise R and Elise S. This will give an understanding to the different gear change points, the turning-in points relating to tyre grip level. It's all there.

Strictly on track

– Lotus Driving Academy

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The Lotus Academy looks like an absolute winner, not only for Lotus, but for those who take part too

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The brainchild of Lotus Sport manager Chris Arnold, the Academy is being administered by Lotus Sport track and events co ordinator Lisa Dann, who is responsible for ensuring that the Academy's pupils understand the ethos behind this structured and multi-tiered approach that will ultimately see graduates gaining their Lotus Academy Licence.

“Getting the Academy up and running has been fantastic,” says Dann. “We’ve devised a programme, enthusiast drivers are going to love. It challenges you all the way and in doing so pushes your natural talents to a new level. Ultimately this course from start to finish is going to mean lots of silverware in the trophy cabinet for the participants who go on and race professionally. I have always thought highly of the Lotus driving programme but wanted to improve the format so that clients were injected with Lotus DNA and would gain knowledge of the engineering and dynamics of the Lotus product.”

“The programme is based on three-competency based stages, Bronze, Silver and Gold, once you’ve passed those you eventually

can have a stab at the much-coveted Platinum Licence, a prize reserved for the most skilled of driver.”

“The platinum licence is the ultimate goal,” says tutor Alastair McQueen. “it’s the endorsement of a driver’s natural alliance with his car, the affirmation that the licence holder not only has a high level of skill but that he/she can strategise, plan an attack of the tarmac, and dominate it.”

The tutelage is centred on giving attendees a technical knowledge so that they understand their influence on vehicle behaviour even before they get behind the wheel. This theoretical instruction is fundamental to each stage of the Academy syllabus and will be assessed accordingly. By working at a steady pace, pupils can rest assured that their knowledge will evolve at each Licence level – just as their practical driving skills will.

At present the activity is centred around the Lotus Cars test track at Hethel, but if successful there is talk that the programme will be available locally to US and European customers.

“We hope that eventually, the Academy programme will be available in all our major car markets,” says Dann.

With the popularity of track driving increasing year-on-year and the skill level needed to win endurance, race and regularity competitions being ever pushed skywards so the demand for driver tuition continues. Drivers want to test themselves and their cars, and learn more about the art of driving and indeed racing. Now, Lotus has heeded that call and what they have on offer will tempt all types of car enthusiast. The Lotus Academy looks like an absolute winner, not only for Lotus, but for those who take part too.

Source: Lotus

www.lotusdrivingacademy.com

Contact Lisa Dann for more information on +44 (0)1953 808547

Well-to-‘two wheels’

– a vision of the future of MotoGP

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This is what racing could be like – a feast of competing technologies not seen since the 1920s

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This article, first published in the February 2009 issue of Bike Magazine, is reprinted by kind permission of its author, Rupert Paul.

It's lap 18 of the Estoril MotoGP, 2016, and the Norton rotary, bankrolled by Malaysian renewable hydrogen fuel giant Petronas, is doing its usual trick of streaking into the lead for six laps, before cutting power to ensure it lasts the race.

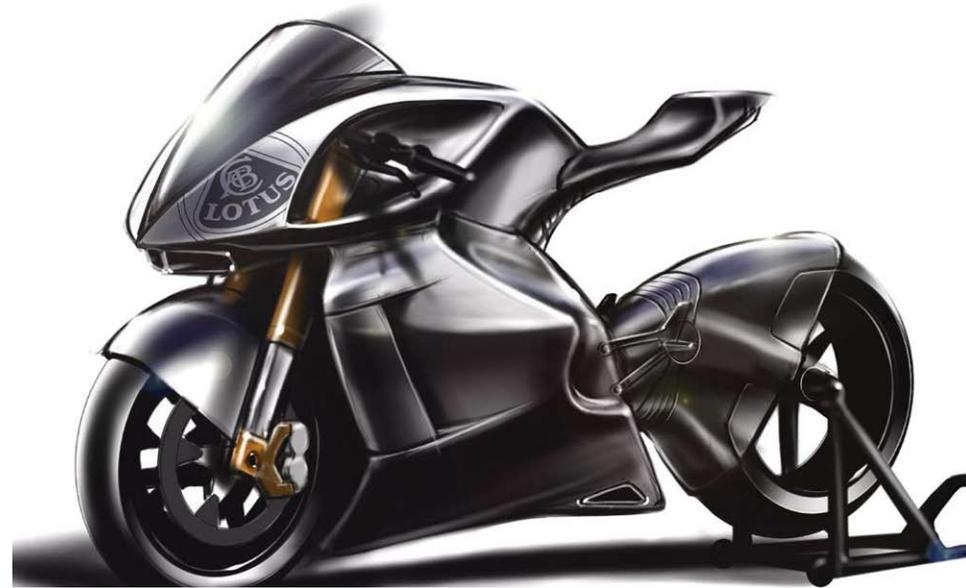
Luca Rossi, little bro of the old master, is powersliding round in second on his 900cc V4 two stroke, built by the newly-merged Kawasaki-Suzuki corporation. There's not a blue haze in sight, and no expansion chambers either. Behind him Taylor MacKenzie, son of Neil, could equal his dad's best GP placing – on a supercharged Zongshen bioethanol triple.

Or could he? Triple world champ Marco Simoncelli is closing fast on his 2WD methanol-powered Yamaha M2. And he's bringing wild card Tom Sykes with him, on the Queen's University Belfast twin-crank, compound pressure-charged LPG-burning single. But in the end, Hiroshi Aoyama wins. It's a blistering day, and his solar panel-faired, regenerative-braking Honda has been quietly stockpiling energy throughout the race. On the last two laps the low-revving 2-litre V5 sprouts another 50bhp, demolishing the competition in imperious style.

This is what racing could be like – a feast of competing technologies not seen since the 1920s. All it would take is one rule: to limit every machine to a fixed amount of startline energy.

That's the vision of world-leading combustion experts Jamie Turner and Richard Pearson at Lotus Engineering in Norfolk. Although they work in the car world, their ideas make equal sense for bikes. They've spent their careers researching powertrain technology, and are now trying to reform the global system of making and regulating cars to head off the twin horrors of global warming and energy insecurity. Their latest move is a paper* to reconfigure motorsport, 'to drive technology for the betterment of mankind'. Their message? Racing needs relevance. It has to start reflecting the challenges we face in the real world.

Rationing energy is not entirely a new idea. After all, today's MotoGP bikes do their stuff on a 21-litre petrol limit – a principle Jamie and Richard believe Bernie Ecclestone should adopt. But they also point out that petrol is only one fuel. There are now cars and bikes out there that run on diesel, ethanol, methanol, fuel cells, batteries and even



hydrogen. All different forms of energy storage, and litres is no way to measure them. For that, you need Megajoules.

Turner and Pearson calculate that an F1 car needs about 4784MJ to complete a race. That means a MotoGP bike, doing 17mpg on fossil-based petrol, uses 669MJ. And if you specify the allowance that way, suddenly every powertrain technology can compete on a level playing field. Top-class racing is transformed into a straight fight for efficiency – which is exactly what the world needs. Forget Carmelo Ezpeleta's decision to scrap the 250s. If he really understood the game he was in he'd have a 650MJ top class, backed by 400MJ and 200MJ classes. If the world championship were being set up today rather than in 1949, that's what it would look like.

And it needn't stop there. Energy rationing drives 'tank-to-wheel' efficiency for all fuels. Why not also use racing to drive efficiency in the way different fuels are sourced, manufactured and transported – the so-called 'well-to-tank' stage?

For example, new player Coskata make bioethanol from woody waste such as straw, leaves and forestry debris. Compared with hauling oil out of the ground, their process has been independently audited to emit 84% less fossil carbon. So if a race team used Coskata ethanol

rather than gasoline, they ought to be allowed more of it. How much more? Turner and Pearson's paper floats a methodology that would give a Coskata ethanol bike 8.4% more startline energy than its gasoline-powered equivalent. For corn ethanol it's 2.9% more, renewable methanol 10.5%, and renewable hydrogen or electricity 10%. To recognise this, there'd be an energy suppliers' championship analogous to today's manufacturer and team championships.

MotoGP's 21-litre limit is a good start, but the bikes are still glorified Manx Nortons. This is a plan that could move the series into the 21st century.

Source: Rupert Paul, Bike Magazine

Following on in the next issue of proActive, Jamie Turner, chief engineer of powertrain research for Lotus Engineering will provide more detail of how energy-based fuel formulae could be applied to future motor sport.

*Turner and Pearson: The Application of Energy-Based Fuel Formulae to Increase the Efficiency Relevance and Reduce the CO2 Emissions of Motor Sport. SAE number 2008-01-2953, presented at the SAE Motorsports Conference”

Lotus and HEVs

- those we can talk about

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Open-mindedness, innovation and vehicle efficiency have always been at the heart of Lotus's engineering ethos

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The automotive landscape is changing at a faster rate than at any time since the birth of the car, impelled by concerns over climate change, air quality and the depletion of the fossil fuels upon which we have all become so dependent.

Consider it a rebirth. Because we're now faced with the same challenging questions that faced the pioneers of motoring. Petrol or diesel? Perhaps biofuels or other alternative fuels. Electric or hybrid? Back when those questions were first posed the answers only had commercial implications; nowadays, in a 'worst case' scenario, the consequences could impact upon the survival of the species.

Even if you dismiss such an outcome as hysterical overstatement, the prospect of 'peak oil' (the point where cumulatively over the years we've used more oil than is left underground) within our generation is scary enough, while in countries such as America, energy security is increasingly a cause for anxiety. No wonder there's tremendous pressure for car manufacturers to 'do the right thing'.

The right thing – precisely what is that? It is, of course, the key issue right now. And it has become abundantly clear that there is no single 'thing'; there are 'things', plural, that will steer us towards cleaner, more efficient vehicles, but we need to determine what are the best solutions for particular applications and keep our eyes and ears open for emerging technologies. What makes this task potentially more difficult is the fact that the car industry, in its broadest sense,

is on the brink of numerous technological breakthroughs, but we still need to implement interim changes while these advances come to fruition.

Keeping track of what environmental solutions are already out there, which are the most important of those waiting in the wings, and which embryonic ideas might show long-term promise, is a time-consuming and complex business. But a vital one. Which is why Lotus Engineering has established a dedicated HEV & EV Technologies division, under the stewardship of Phil Barker, to identify, observe, experiment with and implement the new technologies, as well as consolidate Lotus Engineering's considerable experience in producing efficient, clean and fun to drive vehicles.

It's in the nature of automotive engineering consultancies to go about their business with the minimum of recognition – for the sake of client confidentiality – so it's little known that Lotus Engineering has been working on electric and hybrid vehicles for the past 19 years. In a way that experience extends back 26 years, because the vital control strategy systems required to make gasoline and electric motors co-operate with one another are basically the same as the active systems developed by Lotus Engineering's Control Group for the company's Formula One racing activities.

The company first became involved with a hybrid project back in 1990 and during the following decade participated in several more;

unsurprisingly, activity has intensified over the last five years and has included electric vehicle, or EV, projects too. What's interesting is that the trend towards purpose-built 'green' cars is attracting investment from outside the normal automotive arena, and a number of these start-up car companies have turned to Lotus Engineering for feasibility studies, model making, prototype building, manufacturing advice and more.

It's not just relevant experience that makes Lotus Engineering attractive to these start-up outfits (not to mention major OEMs); it is able to make quick decisions because of its compact internal structure and is flexible because it doesn't have a legacy of large-scale investment in things like engine plants that require a healthy return on their investment.

Open-mindedness, innovation, and vehicle efficiency have always been at the heart of Lotus's engineering ethos, and with so many client projects broadening the knowledge pool over the years, it's perhaps only to be expected that the company is already deeply involved with a number of diverse 'eco-car' assignments.

Of the projects not tightly bound by client confidentiality agreements, the EVE (Efficient. Viable. Environmental) Hybrid is one of the more fascinating, largely because of its near-term relevance. The aim of the project – conducted in conjunction with Lotus shareholder, Proton – was to apply hybrid technology to an existing model range and achieve a 22% reduction in CO₂ emissions. Cost effectively. And quickly.

The base vehicle in this instance was a Proton Gen 2 compact saloon with a 1.6-litre gasoline engine. It was fitted with a belt-driven starter generator to give it start/stop capability; on its own this resulted in a 5% fuel saving. It also had a CVT automatic gearbox to ensure its engine ran at peak efficiency more often. And it had a parallel hybrid system, incorporating regenerative braking, that even with 'old school' metal hydride batteries enabled EVE to run for short distances (up to 5km) on electric power only – with the latest lithium batteries that range is expected to extend to 30km. Even in its first iteration, however, EVE not only achieved the target fall in CO₂ but also posted a 28% improvement in fuel consumption.

Another recent, but entirely different, project was a collaboration with Siemens VDO – now owned by Continental – to create a 'mild' hybrid. Based on a Vauxhall/Opel Astra, this replaced the standard 1.8-litre four-cylinder gasoline engine with a double act of 12kW



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Hydrogen fuel cell technology has been a headline-grabber for the last few years

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electric motor and a downsized gasoline engine, a Lotus-designed 1.5-litre turbocharged three-cylinder unit. Thanks also to some sophisticated combustion technology, this dynamic duo cut CO₂ emissions by 15%, produced fuel economy akin to a diesel, and improved performance over the 1.8. And it was a relatively low-cost solution. It also proved that far from its days being numbered, the spark ignition engine still has lots of potential left to exploit.

Let's abandon internal combustion for a second and turn to pure electric cars. Pure electric cars with a modicum of acceptability with the general public, that is. When a Europe-based lithium battery maker needed a showcase for its technology it turned to Lotus Engineering to convert a Vauxhall/Opel Corsa to electric-only power. To help maintain a sense of normality, Lotus Engineering retained the clutch pedal and gearstick so that it could be driven like a gasoline version. More crucially, however, were the facts that the electric Corsa had a 90-mile range so potentially could be used every day, and it could be charged overnight from a domestic power socket.

The current limitations and forthcoming advances in battery technology are areas in which Lotus Engineering focuses much attention. So too is the need for government-level infrastructure – as is being pioneered on a very small scale by Westminster council with its car park charging facilities – to enable greater take-up of electric-powered vehicles.

Hydrogen fuel cell technology has been a headline-grabber for the last few years, and again Lotus Engineering is investigating this as part of a collaborative venture with taxi maker LTI, Intelligent Energy and TRW Conekt. In a project funded by the UK Government Technology Strategy Board, the goal is a zero emission TX4 London cab for use at the 2012 London Olympic Games that is also commercially viable for general use in other cities around the world from 2014.

Also part of the Technology Strategy Board's overall suite of projects is Limo-Green, a luxury hybrid executive saloon capable of CO₂ emissions of just 120g/km. Lotus Engineering is working on this scheme – that involves an advanced drive motor, small battery pack and small prime movers – with Jaguar Cars, MIRA Ltd and Caparo Vehicle Technologies. Lotus Engineering's primary role is to develop the prime mover that will power the Jaguar on non-urban roads; it could also be termed a 'range extender' engine. Because there's no mechanical link between the engine and the road wheels – the engine powers a generator that produces electricity for the motors that drive the wheels and recharge the battery pack – the



engineers have decided to keep the engine spinning at a speed and load range that's best for peak efficiency, which allows all the engine's components and systems to be optimised for these running conditions.

These are just a few examples of the scope of Lotus Engineering's commitment to the future of hybrid and electric vehicles. The company is also looking into quick and easy solutions such as low rolling resistance tyres, advanced lubricants to reduce the internal friction losses of engines and gearboxes, and ways to cut heat loss in cooling systems. Then there are lightweight vehicle structures to consider, packaging efficiencies that arise when drive motors are in the wheels rather than under the bonnet, and alternative construction materials – the recent Eco Elise study used sustainable hemp, eco-wool and sisal in the manufacture of its bodywork and trim and shed 32kg in the process. It is not just automotive technologies that Lotus provides their extensive expertise on however.

Although widely known for its automotive engineering excellence, a 'flow battery' project brings to light the diverse skills base that has been nurtured and refined at its headquarters in Hethel, Norfolk. A novel 'flow battery' was developed, capable of delivering high power capacity for an extended period of time at low cost. The project involved a collaboration of Applied Intellectual Capital (AIC), Electrochemical Design Associates (EDA) and Lotus Engineering.

The resulting technology has a range of key applications, including large scale power storage for use with renewable power generation. The project produced large scale 250kW modules capable of offering up to eight to ten hours of continuous high capacity discharge. Novel flow battery technology, such as that developed in this current programme, is key to improving power supply-demand quality, reliability and efficiency.

It's a confusing and frenetic yet exciting time to be in the car industry, provided you can move swiftly and respond with appropriate technology. As Lotus Engineering has discovered, you have to be adaptable, knowledgeable and be prepared to mix technologies; whole vehicle energy management is critical.

But while automakers rocket ahead to meet the energy and climate-related challenges of the 21st century, legislation and infrastructure lag far behind. The infrastructure won't accelerate until legislation either encourages or demands it – preferably both – but the legislators have yet to grasp the intricacies and ultimate benefits of the new technologies. Educating the legislators could turn out to be as important a task as developing the next generation of hybrid and electric vehicles.

Source: Lotus Engineering

Q&A with Ford's Director of product programs for Ford Asia Pacific and Africa (APA)

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There are also a lot of bright spots for us, too, in terms of the product offering

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In his role as Ford's Director of product programs for Asia Pacific and Africa (APA), Ian Constance is responsible for all aspects of Ford vehicle product development, from strategy and planning through design and engineering to launch in the region's markets. Based in Bangkok, Constance works closely with Ford's regional product development centres, as well as partner operations within Ford's global organisation. On behalf of *proActive*, *just-auto's* editor Dave Leggett recently caught up with him.

DL: What's occupying your time and getting your attention at the moment?

IC: It's pretty clear that times are quite tough everywhere right now and it's not just the auto industry – it's pretty much everyone and everywhere. Nobody is escaping the difficult economic conditions we have at this time. We are challenged in a number of ways, in terms of keeping the business moving forward.

Where we are spending a lot of our time now is keeping focused on the 'One Ford' plan. A key tenet of that is making sure that we deliver a core product portfolio around the world that meets our customers needs – giving them what they want and what they value.

So that's a guiding message. It's about being global and leveraging all of our global capabilities and activities in the context of a core product range. It's somewhat of a guiding light in these difficult times.

There are also a lot of bright spots for us, too, in terms of the product offering.

We are also now launching the new global Fiesta in China. This has been a key project for us over the last couple of years. It's a fantastic product that we are very proud of and extremely confident about how the Chinese market will adopt it.

We have recently launched a major update to the Focus car-line across the region, building on the established strength of the Focus range, and there's a freshening on the Ranger pickup truck, too. We have also just launched the all-new Falcon in Australia and New Zealand – and that car is receiving new accolades every day (just voted car of the year in New Zealand, for example).



DL: From a product development perspective and working across such a big and diverse territory, how are you organised?

IC: Ford has a number of different development sites around the world and around the region. Key development activities take place in APA (Melbourne, Australia) in Europe (Germany and UK) and in North America. Additionally, we are working with one of our centres down in South America, plus there are also other development centres in our region, in China and in India.

The key global ones though are in Australia, Europe and North America.

DL: What do the Chinese and Indian centres do, modify global Ford products for local consumption?

IC: Yes, in both China and India we start off with the localisation of products that come from elsewhere. We have a level of capability in both of those centres. In India they are working on a regional and a somewhat global product that is going to come through the system. In China they are working on some of our freshening activities and it's a question of developing capability.

DL: And you are happy with the way these two centres are developing in terms of skill sets and design and engineering capabilities?

IC: Absolutely. The level of capability, the level of enthusiasm, the desire to learn and also the desire to deliver the products in these low-cost centres constantly impress me. These guys have a good level of education and are prepared to work very hard to learn and to deliver the products.

DL: And do you think the significance of these low-cost centres will increase inside Ford as they take on more global work?

IC: Definitely. There's a desire to combine activities and to network our activities in the region and in low-cost centres – in Asia and the Americas – with our traditional development centres in order to leverage the low-cost element to support the capacity and capabilities that we have elsewhere in the world.

It's about networking and integration, really. It's a process that has been ongoing for a number of years now.

Q&A with Ford's Director of product programs for Ford Asia Pacific and Africa (APA)

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You would see a surprisingly high level of automation even in plants in low-cost markets

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DL: To pick on one model, the Fiesta, can you give me an idea of the main differences between the car sold in Europe and the versions sold locally?

IC: First of all, if you get in to a Fiesta in China or in Thailand, you will find that the car is instantly and undeniably recognisable as a Fiesta that you might have sat in Europe or anywhere else. It is fundamentally the same product. It looks the same, has got the same styling, feel, switchgear in the same place and so on. It's a Ford Fiesta with Ford DNA. The building blocks of the car – things like the platform – are the same.

There are some differences though. In China, for example, there is a different displacement on the engine and that's to give our consumers a price point that falls within the tax regime that applies in China. In addition to this, we've also tailored Fiesta for the local market. One example is the steering feel, which we've made lighter at low speed to suit Chinese customer preferences.

Another example: some new powertrain technology will be introduced with the Fiesta built at AutoAlliance Thailand, which will drive significant improvements in fuel economy in automatics. Why don't we do that in Europe? Well, it will come to Europe, but auto transmission numbers in Europe are much lower, so we are using Asian introduction to drive that refinement. These are subtleties that are driven by local market tastes and consumer requirements.

And there's another overlay on top of that, which is the need to understand trends in local tastes and fashions. There are of course, a lot of global trends and fashions which is why these global products work, but when it comes down to the nitty-gritty of colour and trim you also need to know the local market and be attuned to its preferences.

I should also add that in some parts of the world you have to wade through big puddles in the monsoon season, the likes of which you wouldn't see in Europe, so you have to ensure that the car can operate absolutely faultlessly in those conditions. But those are generally pretty minor things.

DL: Would the suspension set-ups be tweaked for rougher road conditions?

IC: Yes. Once you get off the beaten track in some of these markets you will find the road surface becomes broken and pretty hard work, so we look to give people an easier ride.

DL: From a manufacturing process standpoint are there significant differences of approach to manufacturing at different locations around the world?

IC: Generally, the way we put the car together – what we term the 'bill of process' – is identical throughout the world. That standardisation of the process means we can drive a good quality of event in terms of the assembly process.

However, there may be some subtleties that change. For example, in a low labour cost environment you may choose to build up more of the vehicle in your own factory rather than bringing in a module from a supplier. But that depends on the prevailing business conditions.

But I would stress that the basic, fundamental process of putting the car together will be the same everywhere.

DL: I guess the whole manufacturing process then might be slightly more labour intensive in Asia, where labour is relatively cheap, than say in Europe?

IC: It can be, but against that there are quality-critical processes where you have to have automation, even in a low-cost country. Fitting windscreens and some body-shop processes, for example, really have to be automated to get to the level of accuracy and quality that we demand in our products.

You would see a surprisingly high level of automation even in plants in low-cost markets.

DL: How do you see prospects for electric vehicles and hybrids in your region?

IC: There's no doubt that there will be some interest and some development but my view is that these products in the near-term will struggle to become mass-market products unless there is a significant legislative push behind them.

Q&A with Ford's Director of product programs for Ford Asia Pacific and Africa (APA)

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There are lots of big challenges ahead, but the one I would focus in on is that I'm part of a huge global network

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The reality is that they are still very expensive and affordability is absolutely a key concern in these markets. Okay, there are competitive pressures but there is also the question of disposable incomes – and they remain significantly behind Western markets across much of Asia.

I think there will be activity and it will be interesting to see how governments legislate for it. China has indicated quite strongly that it wants to be a leader in this area, so that's one to watch.

And of course we're watching very closely to see what governments may do and to make sure that we are able to react swiftly to any legislative or regulatory developments.

DL: What about biofuels?

IC: We see ourselves as a leader in this area. We were the first company to put E20 product in the market here in Thailand – we were well ahead of the curve – and we are bringing out more products that can run on 20% ethanol.

We also have E85 vehicles and up to even greater levels of ethanol in our portfolio that we can bring to market.

Clearly, in markets like Thailand where there's still an agricultural surplus, it's really interesting. In Malaysia palm oil is farmed and available in large quantities for bio-diesel products.

So there is plenty of activity going on.

What we have noticed is that there are unique solutions for different markets depending on their circumstances. It varies. Thailand is interested in ethanol, Malaysia is specialising in palm oil for bio-diesel and in China there is an emerging interest in the research and development of cellulosic ethanol.

DL: To stay with China for a moment, how's your relationship with Chinese partner Changan in terms of product development? Do you work closely with them?

IC: We have a good and very solid relationship with them. They have their own product development group that develops the Changan line of products and we don't get involved with them, but what we do have is a level of capability within our joint venture plant that supports us with localisation and ongoing development activities on the vehicle. That works very well, and we also have our own embedded

people in that environment. We are also training up some of the local young, bright engineers and it's all working very well.

DL: How do you see the capabilities of the supplier base – in terms of product development and working with you on that – which you deal with in your region?

IC: It's obviously a huge range, from basic suppliers who churn out parts to the big global suppliers who are setting up in the region. But we are also working with Asian based suppliers who are fully integrated suppliers and have the ability to fully support our development activities.

And there are a number of those suppliers who also support us globally, not just in the region.

There are some in Japan obviously, but I'm also talking about suppliers here in Thailand and in China.

DL: Do you expect your close relationship in the region with Mazda to be impacted by Ford selling part of its Mazda stake?

IC: We still have a number of successful joint activities around the world and have a lot of joint plants in the APA region. There's AutoAlliance Thailand here in Thailand making a range of pickups and that will carry on. There's also the Changan Ford Mazda Automobile (CFMA) production facility in China, which makes Mazda and Ford B-car products. And there is AutoAlliance International (AAI) in the US.

On the product development side we will continue to work with them on those joint products.

DL: What do you see as the big challenges ahead, in your role?

IC: There are lots of big challenges ahead, but the one I would focus in on is that I'm part of a huge global network – North America, Europe, Australia, China...

This week I have been working on a very interesting product with my colleagues from South America, for example.

The reality of that is that we have to keep lines of communication open and make sure the network is running and functions as it should. We have to make sure that we can feedback real time consumer



Q&A with Ford's Director of product programs for Ford Asia Pacific and Africa (APA)

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And that's basically a 24-7 business and the challenge is to keep abreast of all that, keep the network going

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customer data to colleagues working on product in other parts of the world. And it's a two-way thing – making input to colleagues working on product for us and also us working on a product that's going elsewhere and listening. We have to keep a razor-sharp focus on the customer and also on cost, to make it affordable for the customer.

And that's basically a 24-7 business and the challenge is to keep abreast of all that, keep the network going.

DL: What gives you the most satisfaction in your job?

IC: I really enjoy delivering a product to market that we can believe in. I recently did a drive as part of the final sign-off for Fiesta in China and I drove it back-to-back with competitors; it's just a superb product. I know you'd perhaps expect me to say that, but it really is tremendously uplifting to bring a product that you really have great confidence in to the market.

And then when the product has been on sale and people – friends, relations, customers, people you meet on the street – tell you how much they really like it...that's the reward and that's really what it's all about.

Source: just-auto.com editorial team



Ian Constance

Ian Constance is Director of product programs for Ford Asia Pacific and Africa, a position he assumed in early 2006. In this key product development role, he is responsible for all aspects of Ford vehicle product development, from strategy and planning through design and engineering, to successful vehicle launch in the region's markets.

Based in Bangkok, Constance works closely with Ford's regional product development centres, as well as partner operations in Europe, North America and Japan to create products focused on the Asia Pacific customer of needs. Constance has development responsibility for Fiesta, Focus, Mondeo, Transit, Ranger pick-up, and Everest and Escape SUV's.

Prior to this appointment Constance was chief program engineer for the all-new Ford Focus for AP&A markets, where he led a dedicated team of engineers in its design and engineering to specifically meet the wants and needs a new generation of customers. The Focus was developed with information and consumer insights gained through extensive customer research across the region's markets.

Constance also served as vehicle integration manager with the Vehicle Engineering C-Car team at Ford of Europe, where he was responsible for the development of the C1 Global Shared Technologies concept. This concept defines a common process to manufacture new vehicles and collaboration to develop a broad portfolio of vehicle system technologies.

Constance has extensive experience in automotive engineering, including powertrain technology and driving dynamics. Some of the products he had been involved with include the first generation Focus and Mondeo. From 1996 to 1999, Constance worked with the Powertrain Planning and Strategy division for small cars. Earlier, he worked on Powertrain Engineering for C-Cars for more than three years.

Constance first joined Ford of Britain in 1987 under the Engineering Undergraduate Training Program while pursuing his Engineering degree. He officially joined Ford as Manufacturing Engineer in 1991, advancing his career in product development and engineering with significant success.

Constance has a bachelor's degree in Engineering from Aston University and his master's in Automotive Engineering from Loughborough University, United Kingdom.

Constance is a British citizen, and is married with three children.



The North Carolina Centre for Automotive Research

- Inside the new proving ground

The North Carolina Center for Automotive Research (NCCAR) is a new independent, publicly funded vehicle test center in North Carolina, US. Founding partner Lotus Engineering has played a major role in its development from concept to soon to be reality. Here is the story of how it happened.

While discussions date back to 2001, it was in 2004 that North Carolina General Assembly first appropriated funding for the development of an automotive testing facility in North Carolina. The intent was to demonstrate North Carolina's commitment to supporting the growth and development of the industry by developing infrastructure that demonstrated and capitalised on the state's capabilities and resources. Locating a large facility of at least 500 acres is always challenging. However, North Carolina has several advantages: it is a big state (47,718-miles² of land, 123,590km²) with



a modest population of 9.2m; large tracts of available farmland in the eastern region and a temperate climate. Search activities rapidly narrowed to Garysburg, Northampton County in the northeast for many reasons: a 630-acre site was already identified and available adjacent to Interstate 95; land prices were affordable (compared to the Raleigh and Charlotte areas); it is an air quality attainment area; and it has Tier 1 economic development incentive status.

The NCCAR program really started to accelerate when Lotus Engineering came on board as founding partners in 2004. Lotus Engineering Inc. was looking to access vehicle test facilities in the mainland US in addition to its Ann Arbor and Southfield facilities in Michigan and to supplement Group Lotus global facilities in the UK, Germany, China and India. Lotus offered to assist in the design of the NCCAR features with a view to establishing a presence on site once NCCAR was operational.

Building a vehicle test and development center is not cheap. Initial projections were circa US\$30m. The NC General Assembly demonstrated its commitment to this initiative by agreeing to fund a multi-year staged approach. To date, the total funding received from the General Assembly totals US\$14.75 million (allocating US\$7.5m in 2005; US\$3.75m in 2006 and US\$3.5 million in 2007). Additional funding comes from the North Carolina Rural Center (US\$292,500); Tobacco Trust Fund (US\$300,000); Department of Transport (US\$300,000); Golden Leaf Foundation (US\$1m); NC Department of Transport (US\$1.4m) and Northampton County for the NCCAR site purchase (US\$1.8m).

NCCAR test features were determined by market research of 128 industry leaders and users in 2006. In fact, three separate studies were conducted by experienced professionals. Walbridge Aldinger of Detroit (involved in many automotive test facilities in US, including GM and Toyota) evaluated user logistical needs (34 interviews). Automotive market research specialists Martec of Detroit canvassed a very broad range of 65 industry contacts (including OEM's, suppliers, fuels and lube companies etc.). Finally, the University of Michigan Business School evaluated interest from 24 foreign car manufacturers and suppliers from China and India. The outcome was a remarkably consistent message from potential users: top priority is a world-class ride and handling course; second was the provision of multiple vehicle dynamics areas (VDAs) and third, provide visiting users with top-level office and workshop facilities so that they can operate in a confidential 'home from home' environment, potentially 24/7.

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NCCAR test features were determined by market research of 128 industry leaders and users in 2006

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Locating the top priority features (ride and handling course; vehicle dynamics area; client offices and garages) on the 630 NCCAR site was very easy. Primarily because there were very few options! Positioning a complex 4.6-mile (7.4km) ride and handling course on a site with interesting elevations and wetlands limited the choices. Add in an integrated VDA of 670ft (204m) diameter onto the 0.6-mile (1km) main straight and maintain 100ft (30m) of run-off buffer for the course and the options became minimal (see the site schematic on page 16 – wetlands denoted in darker green).

Alastair McQueen (recently retired from Lotus UK) was commissioned to undertake the NCCAR ride and handling course design in 2006. McQueen has worked in vehicle dynamics and testing at Lotus for 42 years and has considerable experience of vehicle test facilities and race tracks around the world (around 55 in total). Alastair's passionate belief is that there is not one "perfect" vehicle test facility

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- Inside the new proving ground

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The design was produced in the time-honoured 'cut and paste' card templates method

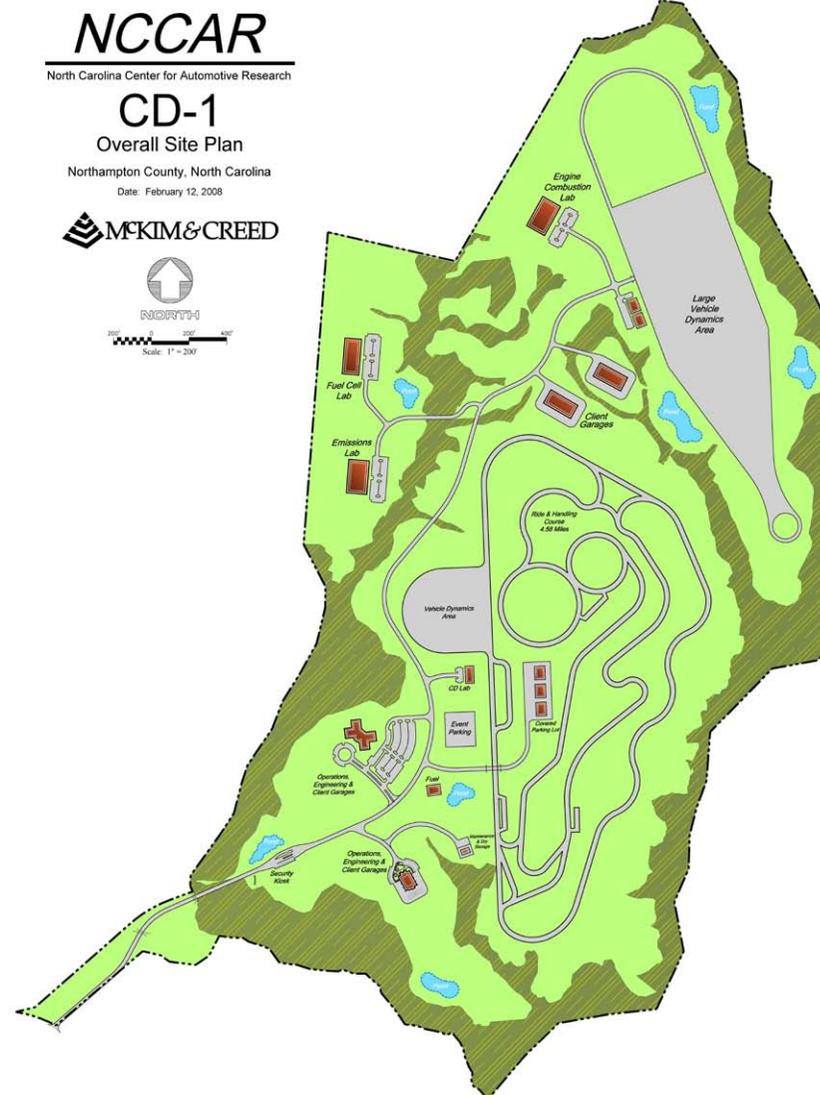
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anywhere. His knowledge and experience has been applied to the design of what is intended to be the premium ride and handling course. The industry benchmark is, of course, the Nürburgring in Germany, as used every year by most premium brands to demonstrate worldwide credibility. NCCAR is designed to provide driver technical challenges, vehicle destabilisation, safety and facility esthetics but without some of the issues of Nürburgring (limited run-off; safety; public oversight; travel distance for non-European users). Key characteristics are the twin turning circles of 450ft & 650ft in diameter (42m and 60m); 30ft (2.7m) of elevation change; 40ft wide (3.7m); five separate bidirectional courses.

The design was produced in the time-honoured 'cut and paste' card templates method, followed by composite photographs of the assembled course and dimensional data. Conversion into AutoCAD was done by NC State University undergraduate Ethan Marshall and then transferred to track design specialists Giffels (of Southfield, Michigan) to produce the blends, fine details of camber and drainage features etc. In parallel, McKim & Creed and S&ME (both of Raleigh, NC) have worked on the site development design and geo-technical surveying, respectively. The critical stage was to overlay the course and VDA onto the site topographical data. The objective being to balance the 'cut and fill' of the earth-works, stay above the water table and ensure the mandated 25ft minimum clearance under the power lines (the power lines minimum hang point changes by 9ft depending on current load and climatic conditions!).

The final 'zero elevation' of the mile main straight was finally fixed at 124.85ft (above sea level) resulting in 704,088 cubic meters of earth-works, with only 1% surplus of stockpiled soils.

Soil types and water table were anticipated to be the biggest challenges on the NCCAR site. Early boring studies (54 locations around the course) indicated a variety of plastic soils, sandy soils, loamy soils, clay soils and a relatively high water table in places (within 15ft of the surface). Hence, French drains are required in areas of high water table and lime stabilisation treatment of clay and plastic soils became necessary. For the corner 23 complex, changes from a -10ft dip to a +10ft peak (relative to the nominal zero level – see



the blue on the schematic left) improved drainage, avoided the water table and reduced the excavations in that area.

The integrated 670ft diameter VDA is sized to facilitate high speed entry maneuvers such as the NHTSA 'fishhook' roll-over test. Ideally, we would have positioned the VDA at mid-point of the main straight, however, wetlands and access to the remainder of the NCCAR site constrained the design (see site schematic).

In terms of construction in progress, the current funding is sufficient to build Phase 1A, as detailed in the schematic above left. This results in a 2-mile (3.2km) ride and handling course (the western section of the full 4.6-mile course), a partial VDA of 670ft x 128ft and the engineering building with six client garages (1,000ft², 93m² each), conference room and offices.

The site clearance has hence been limited to Phase 1A, but with soil positioned for Phase 1B features.

The site is and will remain bordered by natural wetlands and woodlands, offering both confidentiality and exceptional natural beauty, whilst being located only 1.5 miles from US Interstate I95.

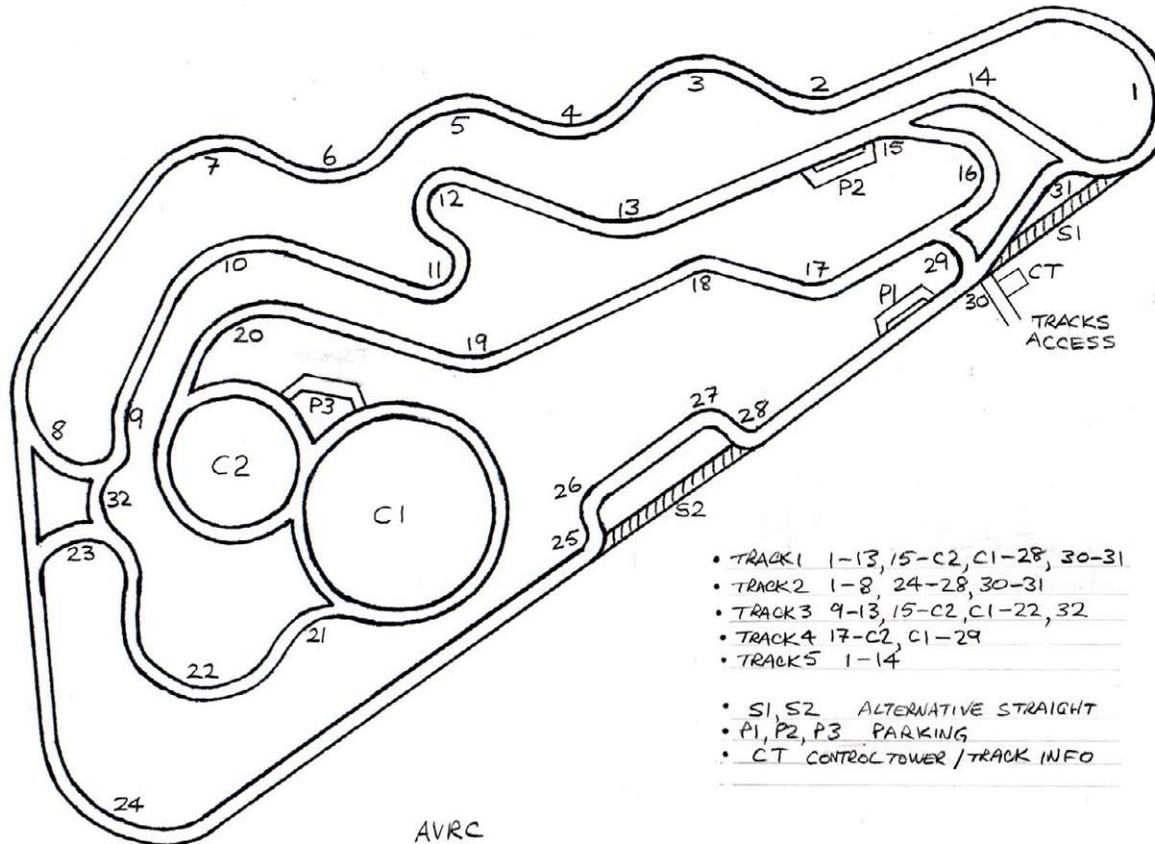
During the NCCAR design and construction stages, the team have developed a comprehensive website (www.nccar.us) and established a considerable number of industry contacts. Some have been so interested in NCCAR that we have received personal advice on technical design aspects and operational protocols. These companies have included GM Performance Division, Chrysler, Ford, Hyundai, Honda America, Volvo Trucks, Firestone Bridgestone, FIA and Driving Safety International.

Site development was awarded to PLT Construction of Wilson, NC in August 2008 with clearance activities starting immediately. Progress to date is ahead of schedule due to better-than-expected soil conditions (including moisture levels) plus good weather. The aerial photograph on the previous page is from December 2008 and shows the development working northwards from the storm-water management systems at the southern point.

The North Carolina Centre for Automotive Research

- Inside the new proving ground

Contact Us



As soon as NCCAR is operational in September 2009, NCCAR will be hosting two clients for immediate research programmes. One is public—the National Science Foundation GOALI collaborative programme to develop driver assistance tools for impaired/elderly drivers (NS State University, New Jersey Institute of Technology, Lotus & NCCAR). The second programme is confidential.

Precise timing and events for the NCCAR opening schedule are yet to be formally defined, but it will certainly include previews for key clients and some interesting vehicles!

NCCAR offers comprehensive facilities for all users—industrial, academic, military, government etc.

NCCAR is a 501(c)(3) non-profit and as such offers contributors a tax-deductible credit for donations. We welcome offers of donations (especially equipment) to help accelerate the pace of technology and education/skills development in North Carolina.

Source: Simon Cobb, Chief Operating Officer, NCCAR

Watch the NCCAR website for updates! www.nccar.us

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